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(54) **MOUNTING PLATE FOR A LASER CHIP IN A SEMICONDUCTOR LASER DEVICE**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**^{7} **H01L 27/15**; H05K 7/20
(52) **U.S. Cl.** **257/81**; 257/82; 257/432; 257/433; 257/706; 257/712; 257/717; 257/720; 257/776; 361/704; 361/709; 361/712
(58) **Field of Search** 257/706, 707, 257/712, 713, 79–82, 99, 431–434, 717, 720, 772, 773, 776, 786; 372/36, 43, 44, 75; 438/26, 51, 106–109, 118, 119, 121, 122, 125, 22, 48; 29/825, 874, 876–879; 361/688, 704, 705, 707, 708–713

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,961,996	A	*	6/1976	Namizaki et al.	438/44
5,636,234	A	*	6/1997	Takagi	372/43
5,638,391	A	*	6/1997	Shima et al.	372/44
5,729,561	A	*	3/1998	Hironaka	372/36
6,172,382	B1	*	1/2001	Nagahama et al.	257/94
6,185,238	B1	*	2/2001	Onomura et al.	372/46
6,195,375	B1	*	2/2001	Hirata	372/46
6,301,278	B2	*	10/2001	Uchida	372/36
6,303,405	B1	*	10/2001	Yoshida et al.	438/46
6,479,325	B2	*	11/2002	Ozawa	438/119

FOREIGN PATENT DOCUMENTS

JP	56027988	A	*	3/1981	H01S/3/18
JP	62252186	A	*	11/1987	H01S/3/18
JP	02278783	A	*	11/1990	H01S/3/18
JP	040726688	A	*	3/1992	H01S/3/18
JP	04186688	A	*	7/1992	H01S/3/18
JP	05021870	A	*	1/1993	H01S/3/08
JP	05041563	A	*	2/1993	H01S/3/18
JP	05102602	A	*	4/1993	H01S/3/18
JP	06283807	A	*	10/1994	H01S/3/18
JP	07235729	A	*	9/1995	H01S/3/18
JP	08228044	A	*	9/1996	H01S/3/18
JP	08264898	A	*	10/1996	H01S/3/18
JP	11054850	A	*	2/1999	H01S/3/18
JP	2001127372	A	*	5/2001	H01S/5/022
JP	2001135885	A	*	5/2001	H01S/5/022

* cited by examiner

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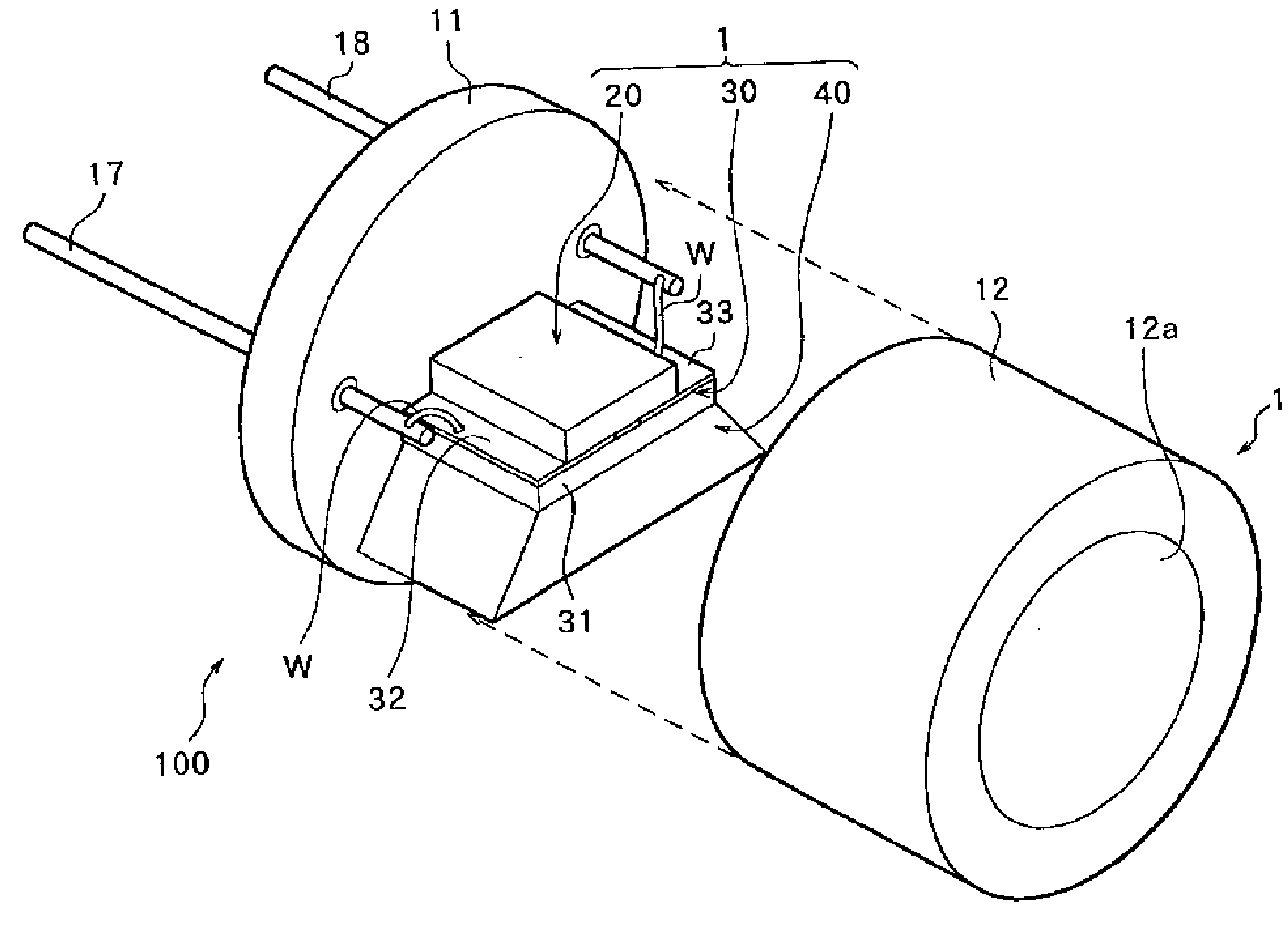
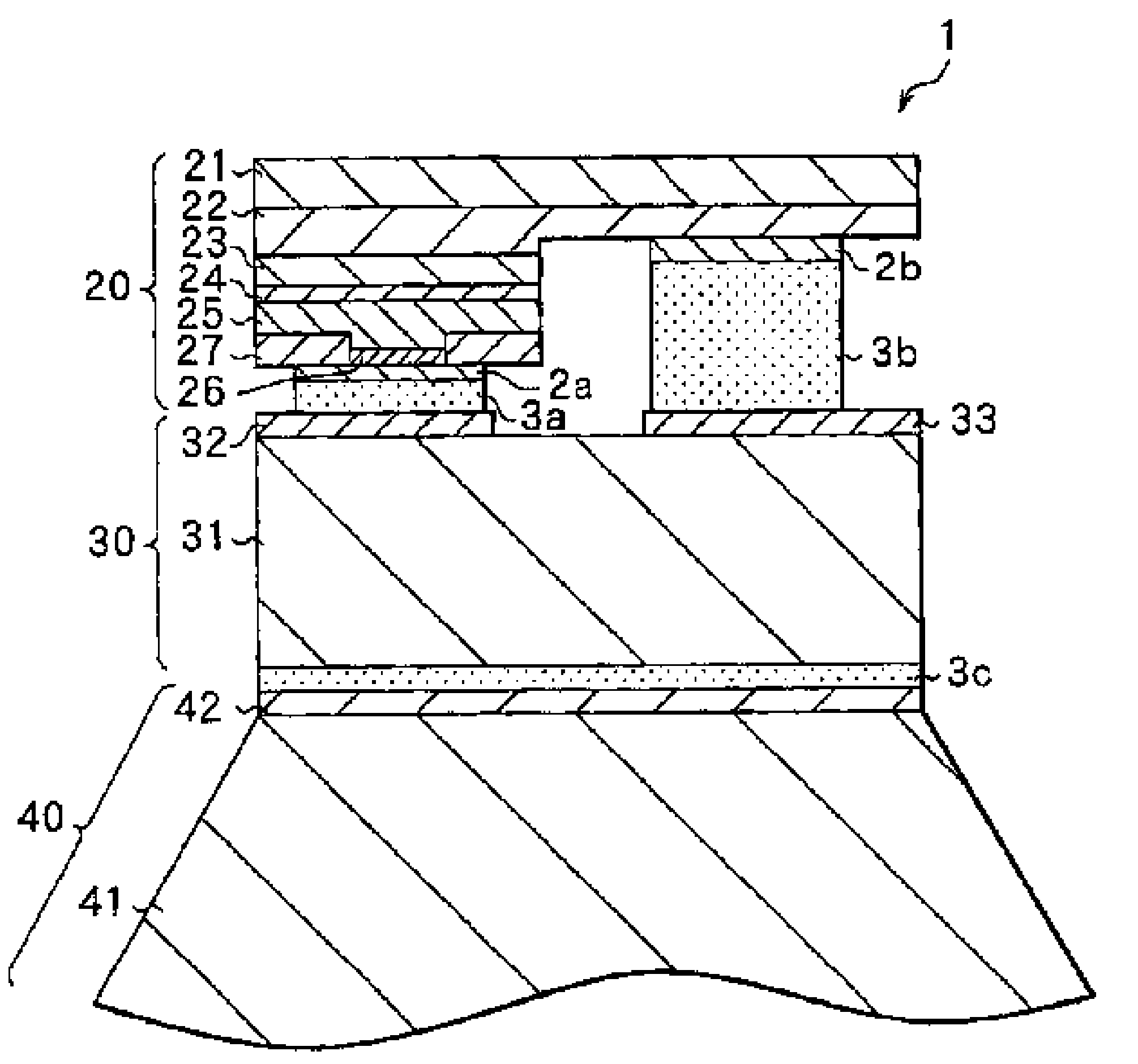
(57) **ABSTRACT**

A method of manufacturing a semiconductor laser device includes the steps of: providing a laser chip, in which a semiconductor layer is formed on a substrate, a supporting plate which supports the laser chip, a mounting plate, a first solder film positioned between the laser chip and the mounting plate and a second solder film positioned between the mounting plate and the supporting plate to form a stacked laser chip structure; applying heat to the stacked laser chip structure sufficient to melt the first solder film and the second solder film; and, applying pressure to the stacked laser chip structure during the heating step to cause simultaneous adhering of the laser chip, the mounting plate and the supporting plate to each other.

5 Claims, 5 Drawing Sheets





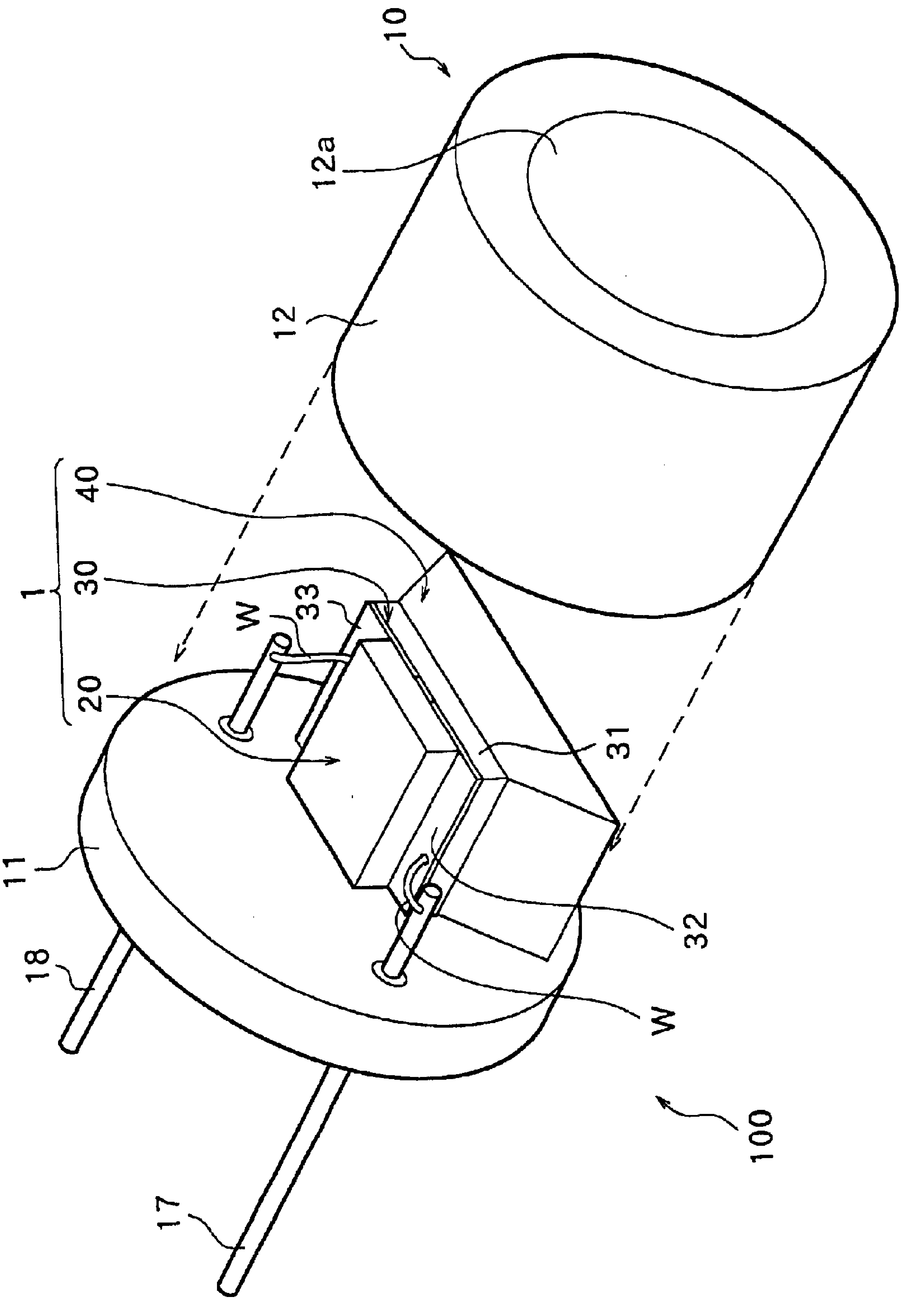


FIG.1

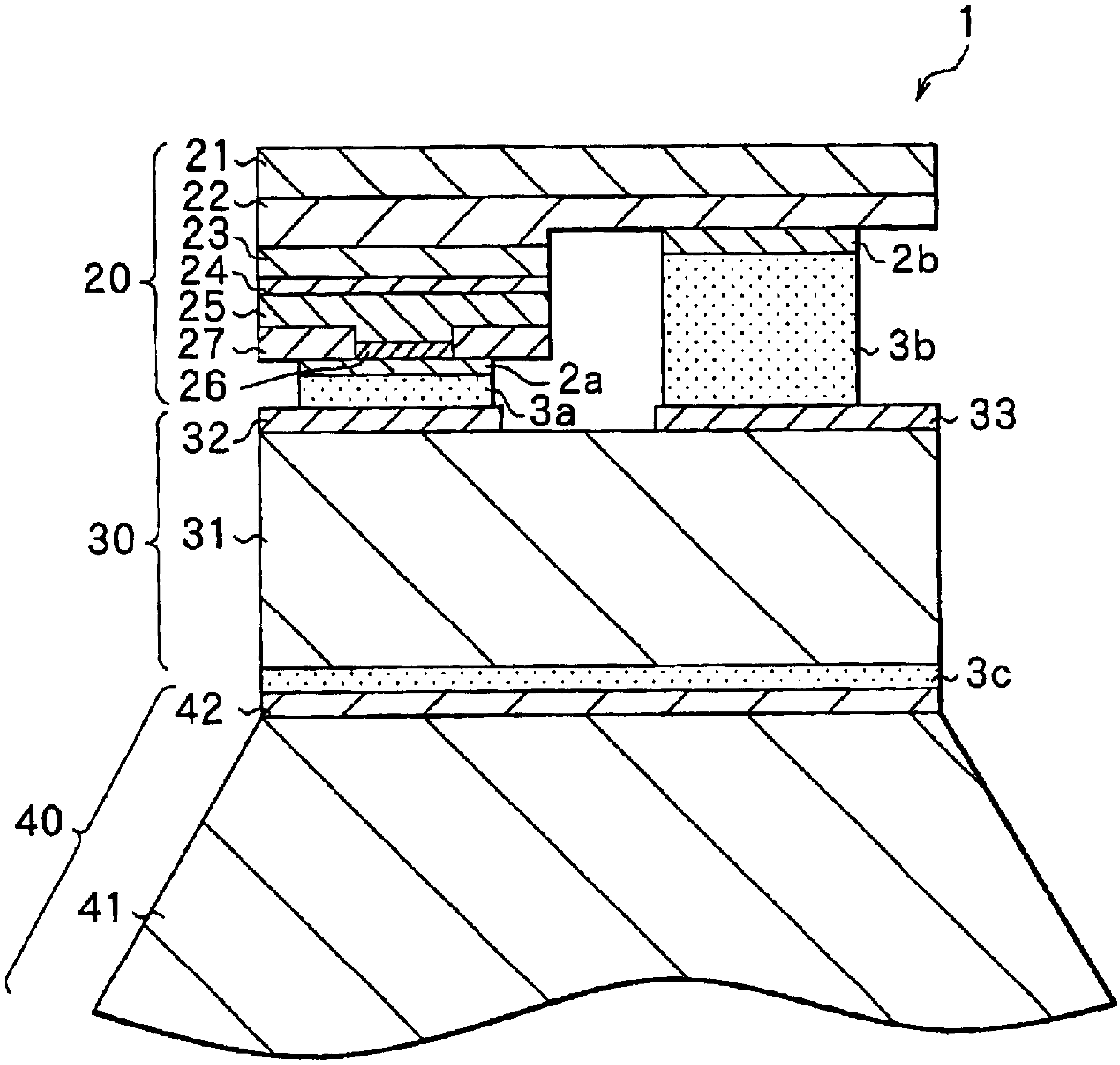


FIG.2

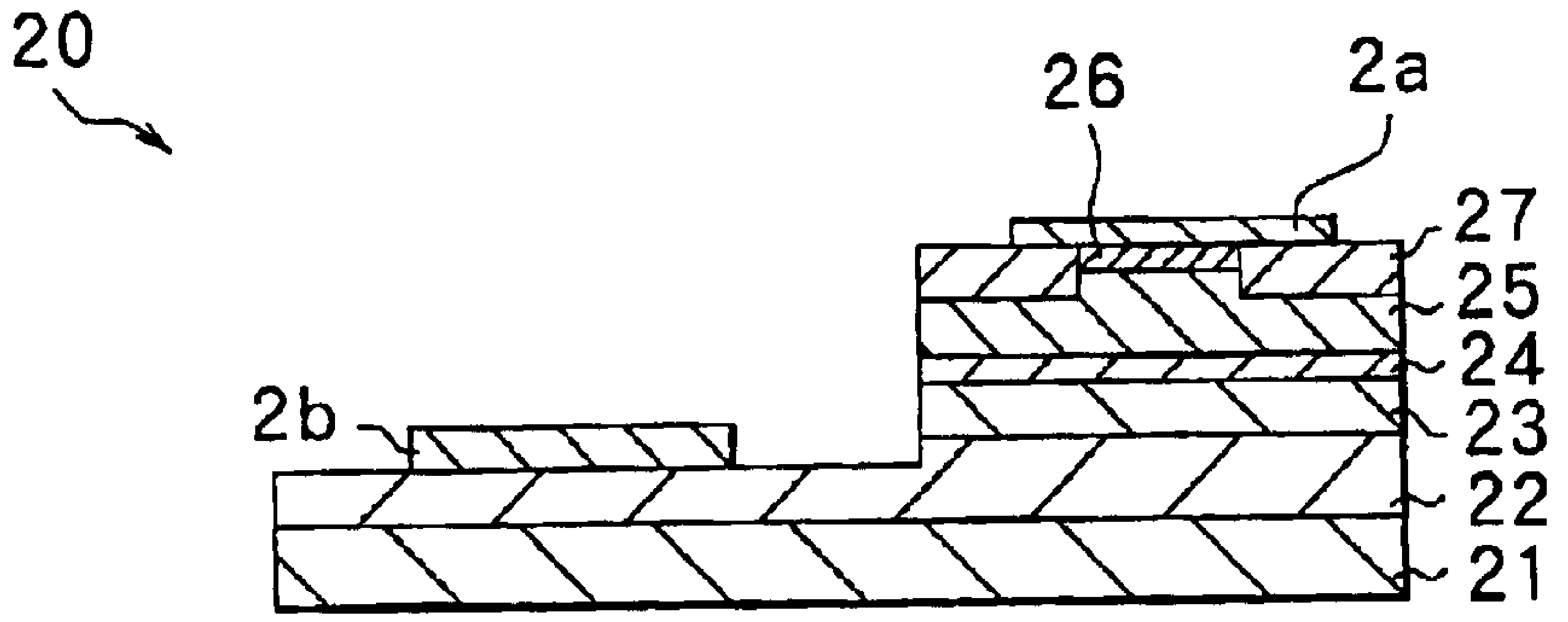


FIG.3

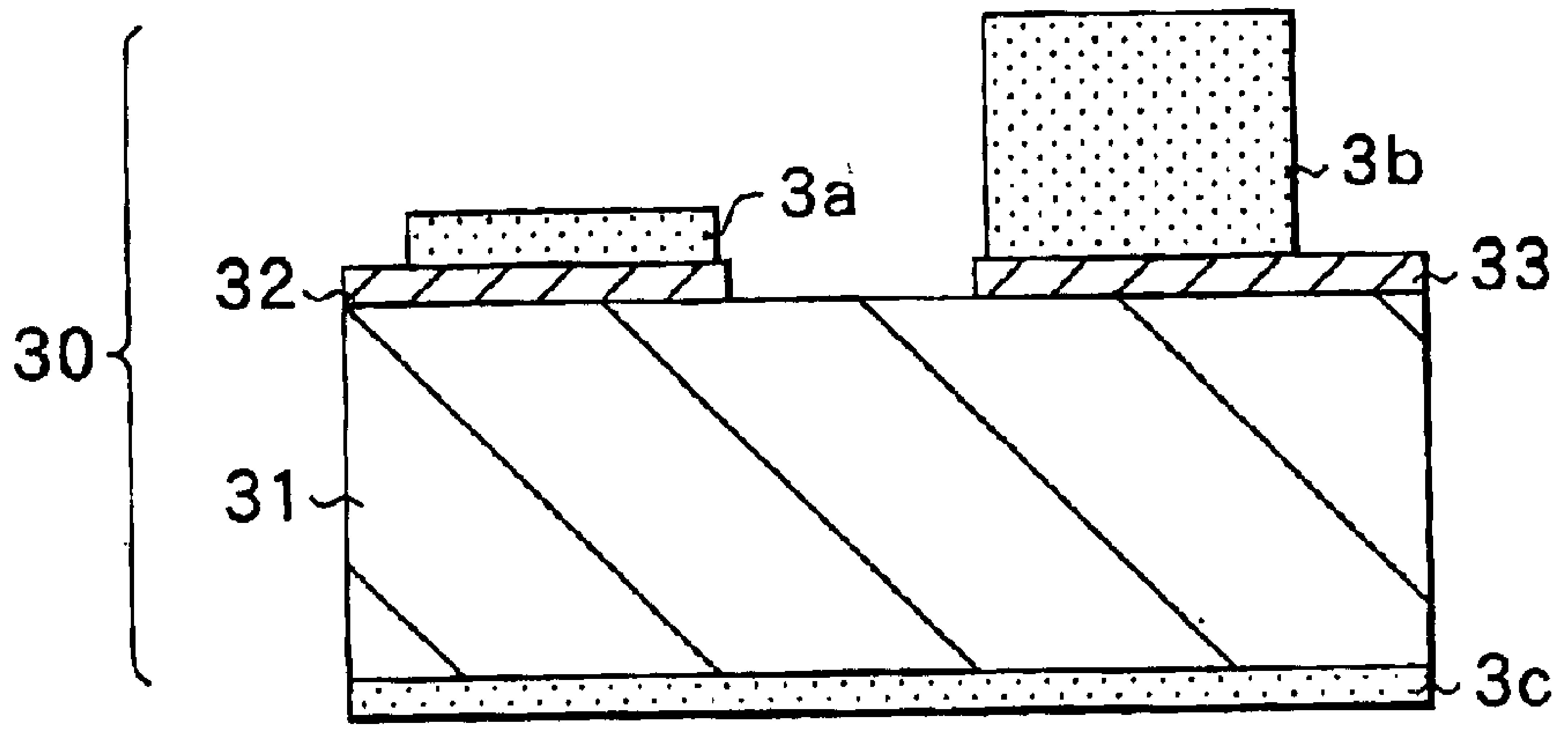


FIG.4

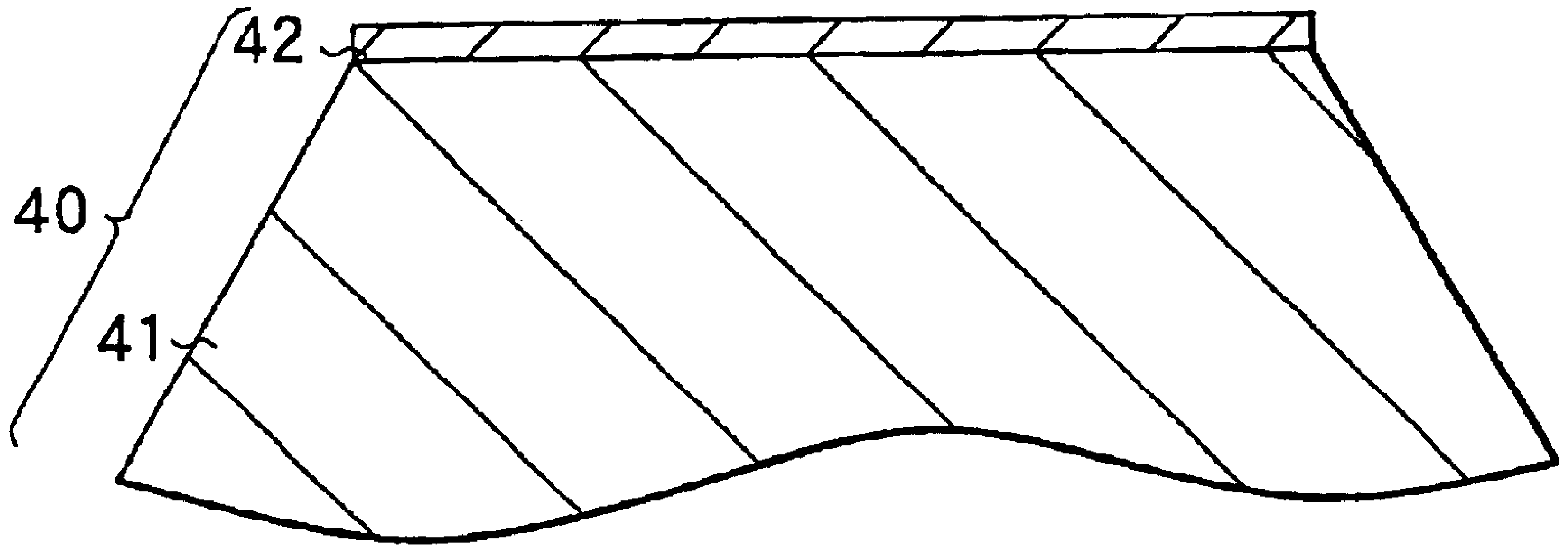


FIG.5

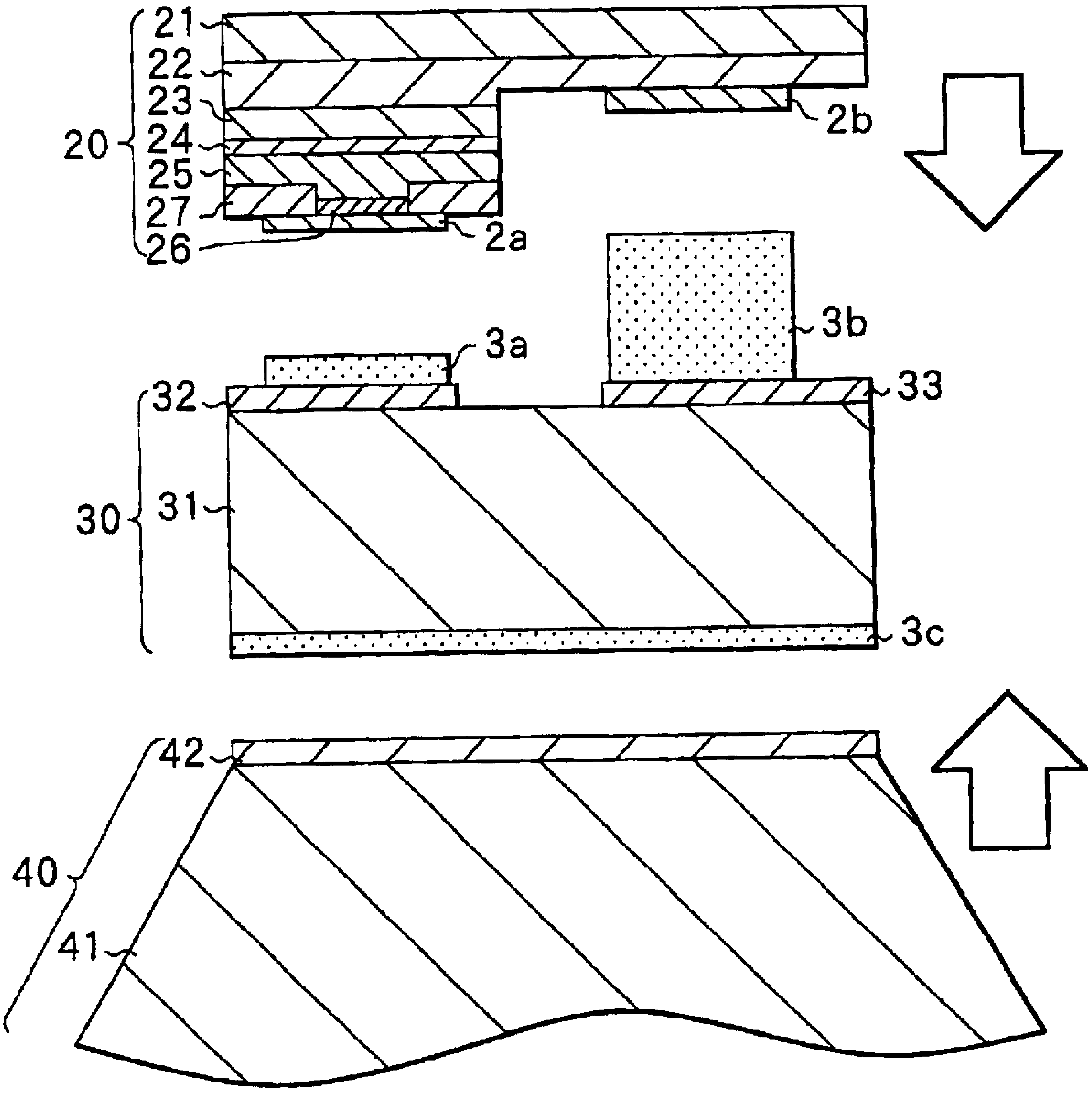


FIG.6

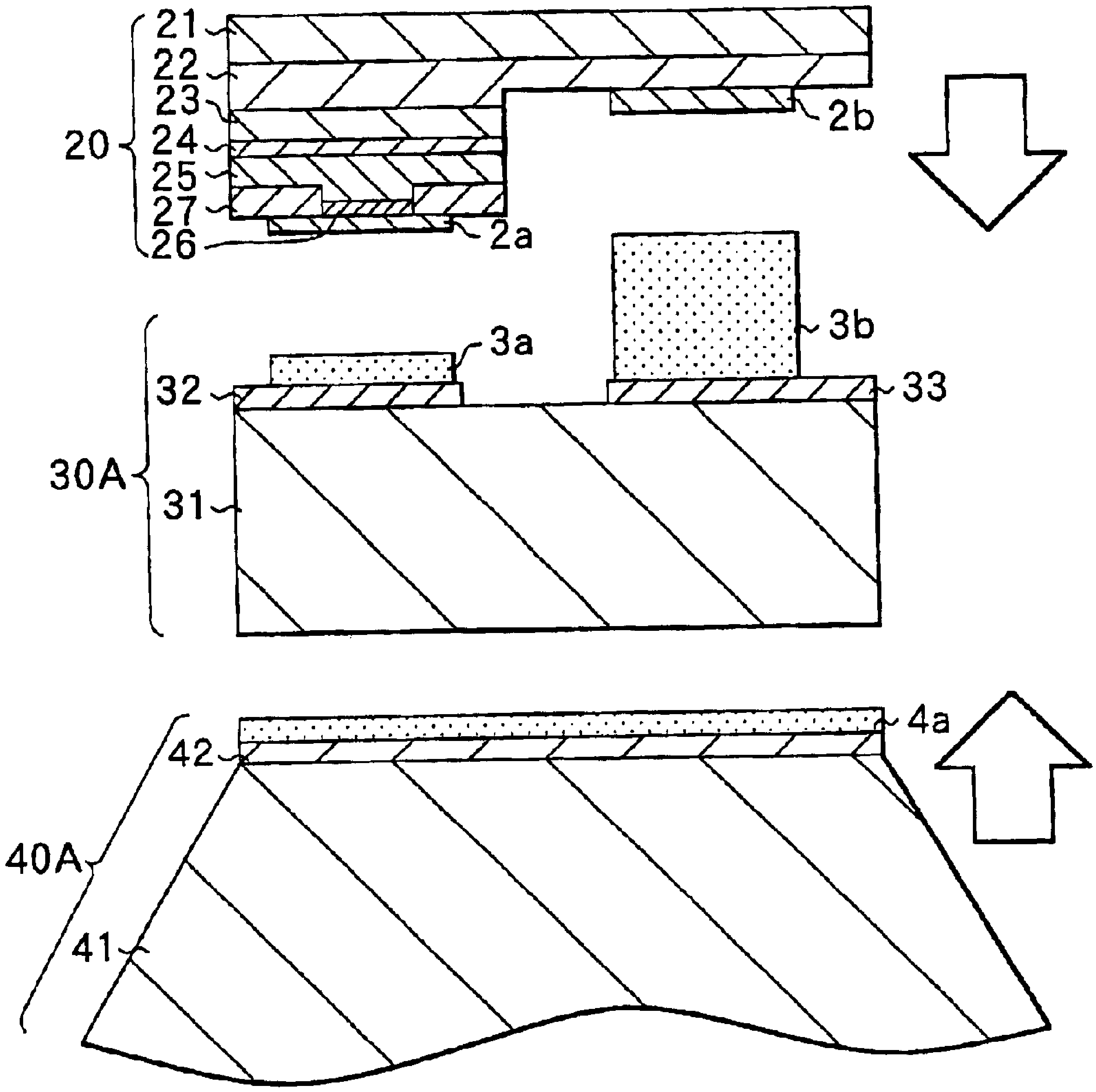


FIG.7

MOUNTING PLATE FOR A LASER CHIP IN A SEMICONDUCTOR LASER DEVICE

This application is a divisional application of Ser. No. 09/729,210 filed on Dec. 5, 2000, now U.S. Pat. No. 6,479,325.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing a semiconductor laser device including a laser chip in which a semiconductor layer and electrode films are formed on the same surface of a substrate, and a mounting plate and a supporting plate which are used in the method of manufacturing a semiconductor laser device.

2. Description of the Related Art

In recent years, semiconductor light-emitting devices including a semiconductor laser device in which a nitride semiconductor such as GaN is employed as a light source for short-wavelength lights have been developed. Generally, with the semiconductor laser device utilizing the nitride semiconductor, an n-type layer, an active layer and a p-type layer, which are made of the nitride semiconductor, are stacked in sequence on a substrate made of sapphire (Al_2O_3). Among a pair of electrode films of the semiconductor laser device, a p-side electrode is formed on the p-type layer which is the most upper layer in the semiconductor layer, while an n-type electrode is formed on the n-type layer which is exposed by etching the p-type layer and the active layer. Here, the substrate, the semiconductor layer, the p-side electrode and the n-side electrode are collectively called a laser chip.

In general, the laser chip is supported by a supporting plate (also referred to as a heat sink) made of a metal with relatively high thermal conductivity, in order for the semiconductor layer to release generated heat effectively. Further, a mounting plate (also referred to as a sub-mount) is provided between the laser chip and the supporting plate, the mounting plate having a lead electrode on a supporting body made with an insulating material. With the conventional method of manufacturing a semiconductor laser device, a solder adheres the mounting plate to the supporting plate and then another solder adheres the mounting plate to the laser chip.

However, with such a conventional method of manufacturing a semiconductor laser device, two steps of adhesion process need to be performed, which creates a problem such that longer time for manufacturing a semiconductor laser device is required. Further, two steps of heating process are needed in order to melt the solder, which causes deterioration in performance of the semiconductor laser device due to repetition of heating.

SUMMARY OF THE INVENTION

The present invention has been achieved in view of the above problems. It is an object of the invention to provide a method of manufacturing a semiconductor laser device capable of reducing time required for manufacture and suppressing deterioration in performance due to heating, and a mounting plate and a supporting plate.

The method of manufacturing a semiconductor laser device of the present invention includes a step for simultaneously adhering a laser chip, a mounting plate and a supporting plate to each other.

The mounting plate of the semiconductor laser device of the present invention adheres to the laser chip, in which a semiconductor layer is formed on a substrate, for use, the mounting plate including a supporting body and a first solder film and a second solder film, each of which are formed on each of a pair of surfaces of the supporting body.

The supporting plate of the semiconductor laser device of the present invention supports the laser chip, which includes a semiconductor layer, having a predetermined mounting plate in between, the supporting plate including a solder film at least on one surface of the body.

With the method of manufacturing a semiconductor laser device of the present invention, the laser chip, the mounting plate and the supporting plate simultaneously adheres to each other, whereby two steps of adhesion process are not needed.

With the mounting plate of the semiconductor laser device of the present invention, the laser chip is placed on one surface of the mounting plate and the supporting plate is placed on the other surface of the mounting plate, thus the first solder film adheres the laser chip to the mounting plate, and simultaneously the second solder film adheres the mounting plate to the supporting plate.

With the supporting plate of the semiconductor laser device of the present invention, the mounting plate is placed on one surface of the supporting plate, whereby the solder film adheres the mounting plate to the supporting plate.

Other and further objects, features and advantages of the invention will appear more fully from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing the structure of a semiconductor light-emitting device in which a semiconductor laser device of an embodiment of the present invention is employed;

FIG. **2** is a cross section showing the structure of the semiconductor laser device in the semiconductor light-emitting device shown in FIG. **1**;

FIG. **3** is a cross section showing the structure of a laser chip of the semiconductor laser device shown in FIG. **1**;

FIG. **4** is a cross section showing the structure of a mounting plate of the semiconductor laser device shown in FIG. **2**;

FIG. **5** is a cross section showing the structure of a supporting plate of the semiconductor laser device shown in FIG. **2**;

FIG. **6** is a cross section showing an adhesion process in the method of manufacturing a semiconductor laser device shown in FIG. **2**; and

FIG. **7** is a cross section for describing the method of manufacturing a semiconductor laser device of a modification of the embodiment according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described hereinafter with reference to accompanying drawings.

First Embodiment

FIG. **1** shows one example of a semiconductor light-emitting device **100** in which a semiconductor laser device **1** is employed according to a first embodiment. The semiconductor light-emitting device **100** comprises the semiconductor laser device **1** and a package **10** in a predetermined shape covering the semiconductor laser device **1**. The package **10** includes a supporting disk **11** and a cylindrical lid **12** to be attached to the supporting disk **11**. One end of the lid **12** in a longitudinal direction is closed but has a window **12***a* through which a laser beam emitted from the semiconductor laser device **1** passes to the outside of the package **10**. The lid **12** is made of a metal such as copper (Cu) or iron (Fe) and the window **12***a* is made of a transparent glass or resin. The supporting disk **11** is made of a metal such as copper or iron and the semiconductor laser device **1** is formed on a surface of the supporting disk **11** (the front face in FIG. **1**). Here, the semiconductor laser device **1** corresponds to one specific example of "semiconductor laser device" of the present invention.

FIG. **2** is a cross section of the structure of the semiconductor laser device **1**. The semiconductor laser device **1** comprises a laser chip **20** including a semiconductor layer, a sub-mount **30** on which the laser chip **20** is mounted, and a heat sink **40** which supports the semiconductor laser device **1** and the sub-mount **30**. The heat sink **40** is made of a metal with high thermal conductivity and releases heat generated by the laser chip **20**. The sub-mount **30** is provided between the laser chip **20** and the heat sink **40** and has lead electrode layers **32** and **33**, each of which is connected to each of electrodes **2***a* and **2***b* of the laser chip **20** to be described later. Here, the laser chip **20** corresponds to one specific example of "laser chip" of the present invention. The sub-mount **30** corresponds to one specific example of "mounting plate" of the present invention. The heat sink **40** corresponds to one specific example of "supporting plate" of the present invention. In FIG. **2** and FIGS. **3** through **7** to be described later, sizes of the laser chip **20**, the sub-mount **30** and the heat sink **40** along the thickness are emphasized.

FIG. **3** is a cross section showing the structure of the laser chip **20** of the semiconductor laser device **1** shown in FIG. **2**. The laser chip **20** includes a crystalline substrate **21** made of sapphire (Al_2O_3). The crystalline substrate **21** may be made of spinel ($MgAl_2O_4$), gallium nitride (GaN), silicon (Si) or silicon carbide (SiC) instead of sapphire. Formed on a surface of the crystalline substrate **21** is an n-type contact layer **22** made of n-type GaN in which n-type impurities, e.g., silicon are doped. The thickness of the n-type contact layer **22** is about 4 μm, for example. Formed on a surface of the n-type contact layer **22** is an n-type cladding layer **23** made of n-type AlGaN in which n-type impurities, e.g., silicon are doped. The thickness of the n-type cladding layer **23** is about 1.2 μm, for example.

An active layer **24** made of InGaN is formed on a surface of the n-type cladding layer **23**. The active layer **24** acts as a so called light-emitting layer, for example, having a light-trapping layer. Formed on a surface of the active layer **24** is a p-type cladding layer **25** made of p-type AlGaN in which p-type impurities, e.g., Mg are doped. The thickness of the p-type cladding layer **25** is about 0.8 μm, for example. Formed on a surface of the p-type cladding layer **25** is a p-type contact layer **26** made of p-type GaN in which p-type impurities, e.g., Mg are doped. The thickness of the p-type contact layer **26** is about 0.3 μm, for example. A part of the p-type cladding layer **25** and the p-type cladding layer **26** is etched. A restricting layer **27** made with an insulating film such as silicon oxide or alumina (Al_2O_3) is provided so as to sandwich the p-type cladding layer **25** and the p-type contact layer **26**.

Formed on a surface of the p-type contact layer **26** is the p-side electrode **2***a*. The p-side electrode **2***a* is alloyed by sequentially stacking a nickel (Ni) layer and a gold (Au) layer from the side of the p-type contact layer **26** and then applying heat thereon, for example. A part of the n-type contact layer **22**, the n-type cladding layer **23**, the active layer **24**, the p-type cladding layer **25** and the p-type contact layer **26** is etched and the n-type contact layer **22** is partly exposed. The n-side electrode **2***b* is formed on the exposed surface of the n-type contact layer **22**. The n-side electrode **2***b* is alloyed, for example, by sequentially stacking a titanium (Ti) layer, an aluminum (Al) layer and a gold layer from the side of the n-type contact layer **22** and then applying heat thereon. The p-side electrode **2***a* and the n-side electrode **2***b* are formed in a belt-like shape extending in a direction perpendicular to the sheet of FIG. **2**. The difference in height between the surface of the p-side electrode **2***a* and the surface of the n-side electrode **2***b* is about 3.5 μm, for example.

Here, the crystalline substrate **21** corresponds to one specific example of "substrate" of the present invention. The stack of layers from the n-type contact layer **22** to the p-type contact layer **26** including the restricting layer **27** corresponds to one specific example of "semiconductor layer" of the present invention. The p-side electrode **2***a* and the n-side electrode **2***b* correspond to one specific example of "a pair of electrode films" of the present invention.

A pair of reflecting mirror films (not shown) is formed on both ends of the laser chip **20** in a perpendicular direction to the sheet of FIG. **3**. These reflecting mirrors have the structure of alternately stacking silicon dioxide films and zirconium oxide (ZrO) films, for example. Reflectance of one reflecting mirror is lower than that of the other reflecting mirror. The light generated in the active layer **24** is amplified by reciprocating between the pair of reflecting mirror films and thus the amplified light is emitted from one reflecting mirror films as a laser beam.

FIG. **4** shows a cross section of the structure of the sub-mount **30**. The sub-mount **30** has a structure such that the lead electrode layers **32** and **33**, and front face solder films **3***a* and **3***b* are formed on a supporting body **31** in a rectangular plate shape. The supporting body **31** is made of insulating material with high thermal conductivity such as diamond (C), beryllium oxide (BeO), copper-tungsten alloy (CuW), aluminum nitride (AlN), cubic boron nitride (cBN), silicon (Si) or silicon carbide (SiC). The size of the supporting body **31** is 200 μm in thickness, 0.6 mm in width (length in the right-left direction in the drawing) and 1 mm in depth (length in the depth direction in the drawing), for example.

The supporting body **31** has an even top surface. A pair of lead electrode layers **32** and **33** of, e.g., 10 μm in thickness is formed on the even top surface of the supporting body **31**. The lead electrode layers **32** and **33** may be formed of gold, gold-tin alloy (AuSn) or the like. The lead electrode layers **32** and **33** may have the structure of subsequently stacking a titanium layer, a platinum layer and a gold layer from the side of the sub-mount **30**. As is shown in FIG. **1**, the lead electrode layers **32** and **33** are electrically connected to pins **17** and **18** (FIG. **1**) provided in the supporting disk **11** (FIG. **1**) via wires W, respectively. Alternatively, one of the lead electrode layers **32** and **33** is electrically connected to a back face solder film **3***c* (FIG. **4**) via a lead electrode (not shown). The left lead electrode layer **32** and the right lead electrode layer **33** are spaced about 50 μm. Here, the supporting body **31** corresponds to one specific example of "supporting body" of the present invention. The lead electrode layers **32** and **33** correspond to one specific example of "a pair of lead electrodes" of the present invention.

The front face solder films **3***a* and **3***b* are formed on surfaces of the lead electrode layers **32** and **33** in the sub-mount **30**, respectively. The front face solder films **3***a* and **3***b* are formed of a metal with a low melting point such as tin (Sn), gold-tin alloy, tin-platinum alloy (SnPt), indium-tin alloy (InSn) and indium (In). The thickness of the front face solder film **3***a* in the left in FIG. **4** is about 3.5 μm, whereas the thickness of the front face solder film **3***b* in the right in FIG. **4** is about 7 μm. That is, the difference in height between the surface of the front face solder film **3***a* and the surface of the front face solder film **3***b* is about 3.5 μm. Here, each of the front face solder films **3***a* and **3***b* correspond to one specific example of "first solder film" of the present invention.

The back face solder film **3***c* is formed on the back surface (the opposite surface to the surface where the lead electrode layers **32** and **33** are formed) of the supporting body **31** in the sub-mount **30**. The back face solder film **3***c* is formed of a metal with a low melting point such as tin similar to the front face solder films **3***a* and **3***b* and the thickness is about 4 μm. The back face solder film **3***c* is provided on the sub-mount **30** since it is easier than providing a solder on a structure such as the heat sink **40** (FIG. **5**).

FIG. **5** is a cross section showing the structure of the heat sink **40**. The heat sink **40** has a structure such that a gold layer **42** is formed on a surface of a body **41** made of a metal with high thermal conductivity such as copper by means of plating. The body **41** in FIG. **5** is trapezoidal but may have different shapes. The gold layer **42** is provided in the heat sink **40** because the back face solder film **3***c* made of tin or the like is easily alloyed with the gold layer **42**. Further, gold is a stable metal and an unwanted oxide film is hardly formed on a surface of the gold layer **42**.

Method of Manufacturing a Semiconductor Laser Device

A method of manufacturing a semiconductor laser device of the embodiment will be described hereinafter.

First, the laser chip **20** shown in FIG. **3** is formed. More specifically, the n-side contact layer **22** made of n-type GaN, the n-type cladding layer **23** made of n-type AlGaN, the active layer **24** made of GaIn-N, the p-type cladding layer **25** made of p-type AlGaN, and the p-side contact layer **26** made of p-type GaN are grown in sequence on the surface of the crystalline substrate **21** made of, e.g., sapphire with a metal organic chemical vapor deposition (MOCVD) method.

After growing layers from the n-side contact layer **22** to the p-side contact layer **26**, the p-type contact layer **26** and the p-type cladding layer **25** are partly etched with a lithography method and the restricting layer **27** made with, e.g., an insulating material is formed thereon. Subsequently, the p-side contact layer **26**, the p-type cladding layer **25**, the active layer **24** and the n-type cladding layer **23** are selectively removed to expose the n-side contact layer **22**. Thereafter, the n-side electrode **2***b* is selectively formed on the exposed area of the n-side contact layer **22** and then the p-side electrode **2***a* is selectively formed on the p-side contact layer **26**.

After forming the p-side electrode **2***a* and the n-side electrode **2***b*, the crystalline substrate **21** is cut vertically to the direction along the length of the p-side electrode **2***a* (in a vertical direction to the sheet of FIG. **3**) with a predetermined width. After that, a pair of reflecting mirror films is formed on a pair of side surfaces of the cut semiconductor layer, respectively, and then the crystalline substrate **21** is cut parallel to the direction along the length of the p-side electrode **2***a* with a predetermined width. Thus, the laser chip **20** is formed.

Next, the sub-mount **30** shown in FIG. **4** is formed. More specifically, the lead electrode layers **32** and **33** are formed on the surface of the supporting body **31** made of, for example, diamond, beryllium oxide, copper-tungsten alloy, aluminum nitride, cBN, silicon or silicon carbide by means of plating, sputtering, or deposition. Subsequently, the front face solder films **3***a* and **3***b* made of a metal with a low melting point is formed on the surfaces of lead electrode layers **32** and **33** by means of deposition. The back face solder film **3***c* made of a metal with a low melting point is formed on the back surface of the supporting body **31** by means of deposition method. Accordingly, the sub-mount **30** including the front face solder films **3***a* and **3***b* and the back face solder film **3***c* is formed.

The heat sink **40** shown in FIG. **5** is formed. Specifically, the gold layer **42** is formed on the surface of the body **41** made of metal, for example, by means of plating. The heat sink **40** is integrally formed with the supporting disk **11** (FIG. **1**) or previously mounted to the supporting disk **11**.

As shown in FIG. **6**, the laser chip **20**, the sub-mount **30** and the heat sink **40** are put together. At this time, since the front face solder films **3***a* and **3***b* and the back face solder film **3***c* are formed on the front and back surfaces of the sub-mount **30**, the front face solder films **3***a* and **3***b* are positioned between the laser chip **20** and the sub-mount **30**, and the back face solder film **3***c* is positioned between the sub-mount **30** and the heat sink **40**. In this state, the laser chip **20**, the sub-mount **30** and the heat sink **40** are stacked and then heat and pressure are applied thereon. The weight for the application of pressure is about 5 g, for example. The pressure applied per unit area of the laser chip **20** is calculated to be about 1.2×10^{-4} Pa. The temperature for the application of heat is, e.g., about 280° C. in order to melt the front face solder films **3***a* and **3***b* and the back face solder film **3***c*. The process of the application of heat and pressure is preferably performed in a nitrogen gas (N_2) or hydrogen gas (H_2) or mixed gas of the nitrogen gas and hydrogen gas atmosphere in order to avoid oxidation of the solder films **3***a* and **3***b*.

Thus, as shown in FIG. **2**, the front face solder films **3***a* and **3***b* adhere the laser chip **20** to the sub-mount **30**, while the back face solder film **3***c* adheres the sub-mount **30** to the heat sink **40**. The p-side electrode **2***a* and the n-side electrode **2***b* of the laser chip **20** are electrically coupled to the lead electrode layers **3***a* and **3***b* of the sub-mount **30**, respectively. In this manner, the laser chip **20**, the sub-mount **30** and the heat sink **40** simultaneously adhere to each other and become an integral unit. Subsequently, the lead electrode layers **32** and **33** in the sub-mount **30** are connected to the pins **17** and **18** (FIG. **1**) provided in the supporting disk **11** (FIG. **1**) through wires (not shown), respectively. Thus, the semiconductor light-emitting device **100** shown in FIG. **1** is manufactured.

Effects of the Embodiment

The effects of the embodiment will be described herein later. As shown in FIG. **6**, the laser chip **20**, the sub-mount **30** and the heat sink **40** adhere to each other simultaneously, whereby time required for manufacture is reduced as compared to the case where a process for adhesion of the laser chip **20** and the sub-mount **30** and a process for adhesion of the sub-mount **30** and the heat sink **40** are separately performed. Further, heating is performed only one time, so that deterioration in performance of the laser chip **20** due to repetition of heating is suppressed.

Since the front face solder films **3***a* and **3***b* and the back face solder film **3***c* are provided on the front and back surfaces of the sub-mount **30**, by only applying heat and pressure on the stacked laser chip **20**, the sub-mount **30** and the heat sink **40**, the laser chip **20**, the sub-mount **30** and the heat sink **40** become an integrated unit, whereby the manufacturing process can be made easier. Since all solder films (the front solder films **3***a* and **3***b* and the back solder film **3***c*), which are easy to oxidize, are provided on the sub-mount **30**, only the sub-mount **30** needs to be controlled for prevention of oxidation, which facilitates parts control.

With the embodiment, after stacking the laser chip **20**, the sub-mount **30** and the heat sink **40**, pressure, e.g., 5 g is applied thereon. The effects of application of pressure will be described below. When thermal resistance of the semiconductor laser device **1** manufactured in the embodiment was measured, the thermal resistance was 12K/W. That is, 12K (kelvin) increased per application of 1 W of heat. On the other hand, the semiconductor laser device was formed in such a manner that the laser chip **20**, the sub-mount **30** and the heat sink **40** adhere to each other without applying pressure. The thermal resistance was measured to be 28K/W. Judging from the measurement results, application of pressure on the laser chip **20**, the sub-mount **30** and the heat sink **40** achieves smaller thermal resistance (that is, smaller temperature increase per application of a fixed quantity of heat) as compared to the case where no pressure is applied. As described with the method of manufacturing a semiconductor laser device of the embodiment, by achieving smaller thermal resistance, life of the semiconductor device becomes longer and further certain performance is maintained for a long period of time.

When life of the semiconductor laser device **1** manufactured in the embodiment and life of the semiconductor laser device manufactured without applying pressure are measured, the life of the semiconductor laser device **1** manufactured in the embodiment is 2.5 times longer than that of the semiconductor laser device manufactured without application of pressure.

Modification

FIG. **7** shows a modification of the method of manufacturing a semiconductor laser device of the embodiment. With the modification, instead of forming the solder films on the front and back surfaces of the sub-mount **30**A, solder films are formed on a surface of the sub-mount **30**A and a surface of the heat sink **40**A. The same elements as those of the first embodiment are indicated by the same reference numerals herein later and the description is omitted.

As shown in FIG. **7**, the front face solder films **3***a* and **3***b* are formed on the surface of the supporting body **31** of the sub-mount **30**A (on the lead electrode layers **32** and **33**), and no back face solder film **3***c* (FIG. **4**) as in the first embodiment is provided on the back surface of the sub-mount **30**A. However, a heat-sink-side solder film **4***a* made of a metal with a low melting point such as tin is formed on the surface of the gold layer **42** of the heat sink **40**A. The structure of the laser chip **20** is the same as the structure of the laser chip **20** in the first embodiment. Here, the heat-sink-side solder film **4***a* corresponds to one specific example of "second solder film" of the present invention.

Thus structured the laser chip **20**, the sub-mount **30**A and the heat sink **40**A are stacked and heat and pressure are applied thereon similar to the first embodiment. Therefore, the front face solder film **3***a* adheres the laser chip **20** to the sub-mount **30**A, whereas the heat-sink-side solder film **4***a* adheres the sub-mount **30**A to the heat sink **40**A. Thus, with this modification similar to the first embodiment, the laser chip **20**, the sub-mount **30**A and the heat sink **40**A adhere to each other simultaneously, which reduces time required for manufacture. Moreover, repetition of heating is unnecessary with the modification, whereby deterioration in performance of the laser chip **20** due to heat is suppressed.

Although the present invention has been described by exemplifying the embodiment and the modification of the present invention, the present invention is not limited to the embodiment and the modification and various other modifications are possible. For example, with the first embodiment, the front face solder films **3***a* and **3***b* and the back face solder film **3***c* are formed on the front and back surfaces of the sub-mount **30**. However, the front face solder films **3***a* and **3***b* and the back face solder film **3***c* may be formed taking the shape of a foil and the foils may be inserted between the laser chip and the mounting plate and between the mounting plate and the supporting plate, respectively. Various structures of the semiconductor light-emitting device **100** are possible in addition to the one shown in FIG. **1**.

As described above, according to the method of manufacturing a semiconductor laser device of the invention, the laser chip, the mounting plate and the supporting plate adhere to each other simultaneously, so that the manufacturing process can be facilitated as compared to the case where the mounting plate adheres to the supporting plate and then the laser chip adheres to the mounting plate. Further, when heating is applied in the adhesion process, repetition of heating is unnecessary, whereby deterioration in performance of the laser chip due to heat is suppressed.

According to the method of manufacturing a semiconductor laser device of one aspect of the invention, the first solder film is provided between the laser chip and the mounting plate and the second solder film is provided between the mounting plate and the supporting plate. Thus, the laser chip, the mounting plate and the supporting plate adhere to each other simultaneously with a simple method.

According to the mounting plate of the semiconductor laser device of the invention, the first solder film and the second solder film are provided on the pair of surfaces of the mounting plate, respectively, so that the semiconductor laser device is easily formed by placing the laser chip on one surface of the mounting plate and placing the supporting plate on the other surface of the mounting plate.

According to the supporting plate of the semiconductor laser device of the invention, the solder film is provided at least on one surface of the supporting plate, whereby the semiconductor laser device is easily formed by placing the mounting plate on the supporting plate and placing the laser chip on the mounting plate (having the solder film and the like in between) and then applying heat and pressure as needed.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A mounting plate which adheres to a laser chip in a semiconductor laser device, the laser chip including a semiconductor layer on a substrate, the mounting plate comprising

a supporting body having a flat first surface and an opposing flat second surface.

a first lead electrode layer and a second lead electrode layer disposed apart from the first lead electrode layer, the first and second lead electrode layers formed on the flat first surface of the supporting body, and a first solder film formed on the first lead electrode layer at a first solder film thickness and a second solder film formed on the second lead electrode layer at a second solder film thickness, the second solder film thickness being greater than the first solder film thickness.

2. A mounting plate according to claim **1**, wherein the supporting body is made with an insulating material.

3. A mounting plate according to claim **1**, wherein the supporting body includes a back face solder film formed on and completely covering the flat second surface of the supporting body.

4. A mounting plate according to claim **1**, wherein the second solder film thickness is approximately twice the first solder film thickness.

5. A mounting plate according to claim **1**, wherein the first lead electrode layer has a first lead electrode layer thickness and the second lead electrode layer has a second lead electrode layer thickness, the first lead electrode layer thickness and the second lead electrode layer thickness being equal to or substantially equal to each other.

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